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OCCUPATIONAL HEALTH ASSESSMENT

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AMBULANCES

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ABSTRACT

An occupational health assessment of three (3) Ontario Ministry of Health Ambulances was conducted to determine if a toxic hazard from carbon monoxide existed in the vehicles. The three ambulances were evaluated under four different conditions in both static and city-driving configurations. Analysis of atmospheric air collected within the vehicles during the trial for carbon monoxide produced levels below existing standards for this gas. A toxic hazard was not identified within the ambulances evaluated during this study.

INTRODUCTION

Carbon monoxide (CO) is a colourless, odourless and tasteless gas produced both endogenously and exogenously. CO is produced endogenously during the catabolism of hemoglobin in the human body. This small quantity of CO produced results in a carboxyhemoglobin (COHb) concentration of 0.4 - 0.7 percent. The major exogenous exposure is from incomplete combustion of organic fuels. Vehicle exhaust CO concentrations range from 0.5 - 0.7 percent, depending on the state of maintenance of the vehicle, and may reach lethal concentrations in a closed space in 10 minutes (1). Tobacco smoke contains approximately 400 ppm CO, which is eight times higher than the American Conference of Governmental Hygienists recommended value of 50 ppm CO (eight hour/day exposure) (2). The toxicity of CO is produced through cellular anoxia. The affinity of hemoglobin for CO is approximately 200-250 times that for oxygen. Thus, exposures to even low ambient levels of CO can produce significant COHb levels. COHb is incapable of binding oxygen, thereby reducing the oxygen carrying capacity of the blood. Physiological symptoms such as headaches, nausea, etc. are usually seen at COHb levels above 8-10 percent (Table 1).

TABLE 1

Health Effects of Carbon Monoxide
in the Healthy Adult

Atmospheric CO Concentration (ppm)	Blood Saturation % COHb at Equilibrium	Response
1 - 3	0.3 - 0.7	Normal range due to atmosphere and endogenous CO production
5 - 30	1 - 5	Increase in cardiac output
30 - 60	5 - 9	Reduced exercise tolerance, visual light threshold increased
100 - 200	10 - 20	Headache, visual evoked response abnormal
200 - 300	20 - 30	Throbbing headache, nausea, fine manual dexterity abnormal
300 - 500	30 - 40	Severe headache, nausea and vomiting, syncope
700	50	Coma, convulsions
1000 - 2000	67 - 70	Lethal if not treated

OBJECTIVE

At the request of the Ontario Ministry of Health, the Operational Medicine Section of DCIEM conduct a study of three ambulances belonging to the Ministry to determine if CO levels in the patient compartment area and driver's location were above existing occupational health standards. Concern had been expressed that CO could be entering the vehicles from leakage due to improper maintenance, CO leakage from heater systems, or from city driving in heavy traffic. Levels of CO were measured in both the patient compartment area and the driver's location with heaters on and off, engine idling and city driving to determine if CO levels produced could present a physiological problem to occupants.

METHODS

Instrumentation

Carbon monoxide concentrations were determined in the three vehicles using a Model 2000 Series Ecolyzer direct-readout CO analyzer (Energetic Sciences, Elmsford, NY). The principle of this instrument is based on the electrochemical oxidation of CO to carbon dioxide (CO to CO_2). Continuous monitoring of CO levels were obtained while the vehicles were in the static mode by attaching a strip-chart recorder (Graphtec-Minato-Ku, Tokyo, Japan) to the output of the CO analyzer. In the city driving tests the direct readout method of obtaining CO levels was employed, with readings taken at 5-minute intervals. During this evaluation calibration was carried out prior to and immediately following the test period with known calibration gases of 25, 50 and 75 ppm CO. Nitrogen (100%) was used to zero the CO instruments.

Vehicle Description

Ambulance No. 1 - Vehicle # 77-1103, Lic # AA4-860
Ambulance No. 2 - Vehicle # 80-118, Lic # AP3-696
Ambulance No. 3 - Vehicle # 86-14, Lic # MM6-224

Test Conditions and Sampling

All vehicle tests, both static and mobile, were conducted outdoors. Prior to actual vehicle startup, interior vehicle monitoring was carried out to determine if any residual CO was present at either sampling point location. In all cases, this background monitoring period was for less than 15 minutes.

The different test conditions and the test periods utilized for the evaluation of the three vehicles were as follows:

Condition 1 - Engine running at normal idle, windows closed, both driver and patient compartment heaters off (1 hour period).

Condition 2 - Engine running at normal idle, windows closed, both driver and patient compartment heaters on (1 hour period).

Condition 3 - City driving, windows closed, both driver and patient compartment heaters on (30-minute period).

Condition 4 - City driving, windows closed, both driver and patient compartment heaters off (30-minute period).

For each of the static trials, atmospheric air was drawn from the interior of the vehicles, through 6.35 mm OD polyethylene tubing, by means of the internal pump of the Ecolyzer-Carbon Monoxide analyzers. The sampling rate was determined to be 0.8 L/min with a delay rate of 10 sec ± 5 due to the length of the sampling lines. The driver's location and patient compartment area sampling lines were 11 and 13 meters in length, respectively.

As noted above, the sampling time for the static conditions was for a 60-minute period. For city driving tests, the two sampling periods were reduced to a 30-minute period for each vehicle, as the CO levels had stabilized and were well below existing standards and, therefore, were not considered to be an occupational hazard.

RESULTS AND DISCUSSION

Background CO monitoring within the vehicles under non-running conditions revealed insignificant levels of CO (less than 3 ppm). Prior to conducting the series of tests, CO values of 120 ppm and 155 ppm were measured in Ambulance Numbers 77-1103 and 80-118, respectively. On inspection, it was observed that numerous holes existed in the engine mount covers of each vehicle, thus allowing CO to enter the interior of each vehicle. A similar problem was not observed with Ambulance Number 86-14. The values appearing in Table 2 are those obtained, following initial observation, and the subsequent sealing of each of the observed holes.

The maximum value obtained for CO was 69 ppm under Test Condition 2 (i.e., engine idling and both heaters on). The two elevated values of 69 and 64 ppm, both in Ambulance Number 77-1103, could possibly be accounted for by the poor state of maintenance of the vehicle as well as undetected holes in the engine mount cover. All other CO values measured during the study are considered to be within normal limits and are well below the Threshold Limit Value Guideline of 50 ppm (2). Ambulance Number 77-1103 was not "city driving" evaluated as it was not considered roadworthy.

TABLE 2

Maximum carbon monoxide concentrations (ppm) measured under four different test conditions at two sampling point locations

VEHICLE NUMBER	TEST CONDITION			
	1	2	3	4
Ambulance 77-1103				
Driver Area	49	69	--	--
Patient Area	30	64	--	--
Ambulance 80-118				
Driver Area	26	28	5	6
Patient Area	17	19	4	8
Ambulance 86-14				
Driver Area	3	3	5	3
Patient Area	5	5	3	3

CONCLUSION

The results of this study, under three different ventilation conditions and in both static and city running configurations, demonstrated that no adverse levels of carbon monoxide which could be considered an occupational hazard, in accordance with existing guidelines, were generated by well maintained vehicles (e.g., Ambulances No. 80-118 and 86-14).

Similar results may not be obtained with older ambulances in a poor state of maintenance, as was the case with Ambulance No. 77-1103.

REFERENCES

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